

3/pats

10/540923

<sup>1</sup> JC20 Rec'd PCT/PTO 29 JUN 2005

AUTOMATIC COUPLING DEVICE BETWEEN A MICRO-CHROMATOGRAPH  
AND A MASS SPECTROMETER COMPRISING A TEMPERATURE  
ADJUSTMENT

The invention relates to a coupling device between a chromatograph (or micro-chromatograph) and a mass spectrometer of the type comprising a temperature adjustment at the interface.

5        It forms an improvement to French patent 2817347 that describes an open type interface, while in some embodiments it may concern slightly different couplings, for example the coupling using the closed type interface. We will briefly describe some  
10 considerations extracted from this prior patent to introduce the invention.

The combination of a micro-chromatograph and a mass spectrometer is particularly attractive for carrying out some analyses of gaseous products.  
15 However, care has to be taken to maintain suitable operating conditions for these two completely different instruments. Thus, the micro-chromatograph is provided with a detector on the output side such as a katharometer (or a microkatharometer) to record  
20 chromatographic peaks by the variation in the composition of the eluate that passes through it. However, this measurement is only correct at constant pressure, for example at atmospheric pressure, but the mass spectrometer operates under a secondary vacuum.  
25 Therefore, a determined pressure difference must be produced between the two measurement means when they are close to each other on the instrument, while

protecting against operating inequalities particularly due to pumping of the spectrometer and variations of the gas flow passing through the chromatographic column.

5        In the previous patent, the interface between the chromatograph and the mass spectrometer was open, in other words it communicates with the outside, and the chromatographic column opened up in a capillary tube leading to the mass spectrometer. Communication with  
10 the outside provided a means of maintaining a constant pressure at the katharometer. If the flow from the chromatograph was greater than the flow sampled by the spectrometer and imposed by the physical characteristics of the capillary tube, part of the gas  
15 eluate was rejected outside the instrument and was lost for the measurement. Otherwise, gas entered the instrument from the outside and into the capillary and participated in the mass spectrometer measurement, distorting it.

20        The inventors of this prior patent had adjusted the flow in the mass spectrometer and the flow in the chromatograph by adjustable heating at the interface, after observing that heating at the interface reduced the gas flow inlet into the capillary tube of the mass  
25 spectrometer, while cooling increased this flow. It was proposed to examine the background noise signal from the mass spectrometer to detect gas entering from outside and to keep this gas quantity as small as possible in order to equalise flows passing through the  
30 spectrometer and the chromatograph, as much as possible. If outside air surrounded the instrument and

could penetrate into it, it was recommended that peak intensities of water, nitrogen and oxygen in the mass spectrometer should be monitored; an increase in the peaks characteristic of air, in other words the nitrogen and oxygen peaks relative to the peak characteristic of water, was a sign of an entry of air. The operator could then adjust the temperature at the interface to correct the flow accordingly.

Unfortunately, it became apparent that this process could not easily be automated. Therefore the purpose of the invention is to provide a device capable of adjusting flows between the detector of a chromatograph and a mass spectrometer on the output side, as efficiently as in the previous patent but automatically. The proposed solution consists of adopting another measurement to make the temperature adjustment. There are several attractive possibilities based on the measurement of a leak or a pressure at an appropriate location of the instrument.

The pressure is a simple parameter directly correlated to a flow irregularity, and it can therefore be used easily by a usual slaving means while enabling an almost immediate correction. The measurement location will often be at the interface between the chromatograph and the spectrometer, but it can also be elsewhere, further on the output side and particularly at the spectrometer; devices with fairly different appearances could be recommended depending on the nature of the interface (open or closed).

The invention also relates to an analysis device comprising a micro-chromatograph and a mass

spectrometer, the output from the micro-chromatograph being connected to the input of the mass spectrometer through an automated coupling device according to the previous definition; and which may also be provided on the input side of the micro-chromatograph with a pre-concentration device based on adsorption followed by a thermal desorption, for example the Airsense<sup>®</sup> "μTD" pre-concentrator.

The invention will now be described with reference to Figures 1, 2 and 3 that show corresponding embodiments of the invention.

Figure 1 illustrates an instrument on which the invention could be implanted. It comprises a chromatographic column 1 supplied on the input side by a vector gas source or an eluent and by an injector of the product to be analysed or soluted. The chromatographic column 1 is heated to the required temperature in an oven 4. It is known that components of the product to be analysed pass through the column 1 at different speeds depending on their chemical affinity with a specific stationary phase contained in it. A microkatharometer 5 is arranged at the output from the column 1 and measures variations in the gas composition passing through it in a known manner. The column continues as a tube 6 beyond the microkatharometer 5, that usually does not contain any stationary phase and in which the gases can circulate. A capillary tube 7 is housed in the tube 6 and prolongs it as far as a mass spectrometer 8 that makes another measurement on compounds separated by the chromatograph. The tube 6 comprises at least one

opening 9 not far from the end of the capillary tube 7 so as to maintain the pressure at the microkatharometer 5 equal to an invariable value, according to the advantage of this open interface between the column 1 and the spectrometer 8. The essential property of the capillary tube 7 is that it only allows passage of a maximum gas flow that depends on the temperature. If the flow output from column 1 is greater, the excess leaks from the tube 6 at the opening 9; otherwise, the surrounding gas enters into the tube 6, then into the capillary tube 7, and ends up in the mass spectrometer 8 if this condition is maintained.

According to one embodiment of the invention, it is intended to place a gas leak detector 10 at the opening 9. It may also include a microkatharometer and operate starting from the difference in thermal conductivity between the ambient gas and the leakage gas. It comprises a suction probe 11 placed at the opening 9. The leak detector LD 228 made by the GL Sciences Company has for example a sensitivity of 0.01 ml per minute, which is sufficient to give good results in the application considered.

Other detectors and particularly flow meters could be envisaged, for example of the Honeywell ® "AWN 40000 Series" type, also sensitive to a variation in the thermal conductivity. The advantage is that it is easier to retrieve the measured signal to subsequently control regulation of the interface temperature.

The signal from the detector 10 is input to a control module 12 that acts on a temperature adjustment means 13 of the interface. In a manner similar to the

previous patent, this means 13 may consist of an electrical circuit comprising a heating resistance 14 for example located close to the mass spectrometer 8. Preferably, the means 13 must consist of a uniform  
5 heating system as long as the maximum length of the capillary tube 7. In this case, it is an adjustable element 15 on which the control module 12 acts as a function of the signal from the detector 10. The control module 12 may comprise an electronic card or an  
10 analogue calibration means giving an adjustment of the element 15 as a function of the received signal expressing the difference with a required state.

Figure 2 illustrates another embodiment similar to the previous embodiment, except that the detector 10 is  
15 replaced by another pressure detector 16 connected to the chamber 17 of the mass spectrometer 8. In a known manner, for example the Hewlett-Packard® "HP59864" ionisation gauge, can be used to estimate the pressure in the chamber 17 starting from the air density  
20 measured in the mass spectrometer. The detector 16 inputs data to the control module 12 in the same way as the previous detector 10, while the remainder of the instrument remains unchanged. It was found to be perfectly possible to adjust the heating at the  
25 interface using the pressure in the chamber 17. In this embodiment, the interface remains open.

Figure 3 illustrates a closed interface. The tube 6 no longer communicates with the outside, such that the only outlet for the eluate is the capillary tube 7.  
30 The closed interface was not considered in the previous patent, but improvements in this patent can be applied

to it. For example a pressure sensor 18, for example  
the Sensor Technics® "HCX Series" sensor could be  
fitted at the end of the tube 6 to measure the pressure  
of eluate in it, and to slave it to a fixed value that  
5 guarantees that flows will be equal. Once again, the  
interface temperature is controlled by the control  
module 12 and the electrical heating circuit.